**In this activity you will be “collecting” information from a web-based resource. Go to:** [**http://violet.pha.jhu.edu/~wpb/spectroscopy/basics.html**](http://violet.pha.jhu.edu/~wpb/spectroscopy/basics.html)

**Light as energy**

Light is remarkable. It is something we take for granted every day, but it's not something we stop and think about very often or even try and define. Let's take a few minutes and try and understand some things about light.  
  
Simply stated, light is nature's way of **(1)\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_**energy through

**(2)\_\_\_\_\_\_\_\_\_\_\_\_\_\_.** We can complicate it by talking about interacting electric and magnetic fields, quantum mechanics, and all of

that, but just remember--*light is* ***(3)\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_*.**  
  
Light travels very rapidly, but it does have a finite velocity. In vacuum, the speed of light

is **(4)\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_** miles per *second* (or nearly 300,000 kilometers per second), which is really humming along! However, when we start talking about the incredible distances in astronomy, the finite nature of light's velocity becomes readily apparent.

It takes about **(5)\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_** seconds, for instance, for a radio communication travelling at the speed of light to get to the moon and back.

**Particles and Waves**

Physics experiments over the past hundred years or so have demonstrated that light has a dual nature. In many instances, it is convenient to represent light as a "particle" phenomenon, thinking of light as discrete

"packets" of energy that we call **(6)\_\_\_\_\_\_\_*\_\_\_\_\_\_\_\_\_\_\_\_\_\_*.** Now in this way of thinking, not all photons are created equal, at least in terms of how much energy they contain. Each photon of X-ray light contains a lot of energy in comparison with, say, an optical or radio photon. It is this "energy content per photon" that is one of the distinguishing characteristics of the different ranges of light described above. Even though it is not strictly correct, it is hard not to think of a beam of light as a collection of little "light bullets" all strung together in a row.

***Copy & paste a labeled image of a wave in the space below.***

**(7)**

***Describe how you measure wavelength.***

**(8)**

The colors of the familiar "rainbow" of **(9)\_\_\_\_\_\_\_\_\_\_\_\_\_** light correspond to differing wavelengths of the light, here shown on a nanometer scale. The wavelengths get successively larger as one moves from left to right. Optical light

runs from about **(10)\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_** to **(11)\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_** nanometers. ***Copy and paste an image of the visible light spectrum below.***

***(12)***

**The familiar "rainbow" of the visible spectrum can be converted into a graph that shows how the intensity of the light changes along the spectrum. Copy and paste the graph below. (13)**

**(14) What colors have the greatest intensity?**

Astronomers use graphical spectra most of the time because they can get more information out of the light this way, and because they can still plot and analyze

light that is not directly

**(15)\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_**to our eyes!

Now we mentioned that the energy of each photon of light was also a basic property. It turns out that there is a simple relationship between the energy of a photon and the corresponding wavelength of that photon:

***Copy & paste the equation that represents this relationship.***

***(16)***

### Interaction of Light with Matter: Absorption and Emission of Light

It should come as no surprise to you that **(17)\_\_\_\_\_\_\_\_\_\_\_\_\_** and ***(18)\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_*** (which are simply bound collections of two or more atoms) can absorb light (= energy!). If they didn't, you could simply flick a light on and off, and then sit back

while the photons continued to **(19)\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_** around the room!

Likewise, **(20)\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_** light (= heat = energy!) wouldn't do any good in heating up your home in the winter if it didn't get absorbed by matter. Higher

energy light photons, like **(21)\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_**, tend to want to plow through more matter before they get absorbed. (Hence, their use in medical imaging: they can pass through your "soft" tissue, but are more readily absorbed in your bones, which are denser.)

**(22) How and why do photons get absorbed by matter?**

Extending this a bit, it should become clear that since every chemical element has its own unique set of allowed energy levels, each element also has its own distinctive

pattern of **(23)\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_** absorption (and **(24)\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_\_)** lines! (See diagrams above for neon, for example.) It is this spectral "fingerprint" that astronomers use to identify the presence of the various chemical elements in astronomical objects. Spectral lines are what allows us, from a "spectrum," to derive so much information about the object being observed!

**(25) Copy and paste Neon’s spectral “fingerprint” below:**